2009 JPL SURP Strategic Topic Areas

Topic Area:	2. Determining the Geometry and Structure of our Universe
Champion(s):	To be announced

Cosmology and Fundamental Physics are entering a new era in which we will have precision tests of our ideas of cosmology and relativity. We have firm evidence that dark matter comprises approximately 23% of the energy density of our universe. There is also strong evidence that the universe is very close to a spatially flat geometry on the largest scales. Evidence has also been accumulating in the past decade that the expansion of the universe is accelerating, driven by an unknown cause, which we have termed “dark energy”. With the ground-based *LIGO* gravitational wave observatory, we are poised to make the first direct detection of gravitational waves. The recent *WMAP* and the upcoming *Planck* missions will measure the Cosmic Microwave Background, the radiation left over from the hot dense phase of the early universe. These missions will provide precision measurements of several fundamental cosmological parameters. In addition to this current work, there are several space mission concepts that promise even higher precision measurements of the fundamental nature of our universe. The *JDEM* (Joint Dark Energy Mission) mission concept would place strong constraints on the nature of dark energy. A future Cosmic Microwave Background Polarization mission could potentially detect the gravitational wave signature of the epoch of inflation in the early universe. *LISA* (Laser Interferometer Space Antenna) could observe the inspiral merger of black holes, providing tests of general relativity and potentially providing accurate distances to the merger events allowing further tests of cosmology.

Approach:

In order to realize the promise of current and future missions, much progress is needed in several fronts. These include detector development, data analysis techniques related to handling very large data sets with high speed, pioneering ground-based observations to validate observational techniques and detectors, and control of systematic error. While we cite below specific examples based on anticipated future missions, we are open to other innovative techniques to probe these and related questions in Cosmology.

Potential areas for fruitful research include:

- Cosmic Microwave Background Polarization
    - Development of components and detectors
    - Techniques for calibration, and for evaluating and controlling systematic errors
    - Techniques for data analysis for the very large data sets expected
    - Theoretical analyses aimed at supporting mission optimization and data interpretation
- Dark Energy Measurement Approaches
    - Development of the weak lensing approach, including ground-based tests, hardware development, and simulations of space-based techniques
    - Development of the baryon acoustic oscillation approach, including ground-based tests, hardware development, and simulations of space-based techniques
    - Theoretical analyses aimed at supporting mission optimization and data interpretation
- Gravitational Waves and Fundamental Physics
    - Data analysis and simulation of space-based gravitational wave measurements
    - Development of sensors and detectors for precision tests of fundamental physics that might be best done in space
    - Theoretical analyses aimed at supporting mission optimization and data interpretation